PORTABLE NON-INVASIVE DEVICE FOR LACTATE THRESHOLD DETERMINATION

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Abstract. *Lactate is an important metabolic product that provides an opportunity for analysing a person's physical condition. This paper will focus on the phenomenon of anaerobic metabolic threshold. Receiving an accurate value of this parameter allows designing a precise training plan that corresponds to any goals, from prevention of cardiovascular diseases to achieving high performance in sports disciplines. There are different ways to find out lactate threshold but all of them either handy but not rigour or explicit but invasive. Therefore, this piece will offer options on how to create a minimally sized non-invasive device which allows to integrate a strict low cost, recyclable and convenient for use in any context lactate threshold measurement technology in sports centres and in the lives of people interested in their health and outcomes.*

Keywords: *heart rate, temperature, sensors, lactate, cardio-vascular system, non-invasive measurement.*

Introduction

Consistent aerobic workouts decrease the probability of cardiovascular disease [10]. But the utility of this type of workout depends on prescribed instructions corresponding to individual's specifics. In particular to get the minimum essentials data it's necessary analyse:

HR under load,

lactate concentration in blood/CO_2 concentration in exhaled air.

Existing methods of measurement of this data derives into two main categories: laboratory analyses and portable devices. Former provides precise values but requires distinctive equipment with its operator and qualified specialist in sport medicine whereas latter is very easy to use but cannot give accurate data. The solution of this problem can be a portative non-invasive device for defining all above-mentioned parameters during step test which causes the aerobic and anaerobic metabolic pathways to activate.

Application field is really wide. The final solution can be useful for everyone who's interested in safety and efficient ways of training.

Cell metabolism. Lactate threshold.

In this section we'll talk about process of synthesis of ATP applicable to physical effort. The synthesis starts from glycolysis which splits glucose into two pyruvate molecules [1].

After the first ten steps of glycolysis, the chemical perturbations with pyruvate are determined by the cell's microenvironment. The enzyme *lactate dehydrogenase* can convert pyruvate to lactate in cells that lack mitochondria, have inadequate oxygenation, or whose energy demand has grown too quickly for oxidative phosphorylation to produce enough ATP. In this stage, NADH and H+ are oxidized to NAD+, which permits glycolysis to proceed via the *glyceraldehtde-3-phosphate dehydrogenase* process [1].

Under aerobic conditions pyruvate and co-products enters mitochondria where occurs citric acid cycle (TCA) thereafter oxidative phosphorylation happens.

The main difference between anaerobic and aerobic glycolysis is reaction velocity. When skeletal muscle cells contract quickly and require more energy than can be supplied though oxidative phosphorylation alone, anaerobic glycolysis speeds up the synthesis of ATP. The rate of glycolysis is around 100 times higher than that of oxidative phosphorylation [1].

Whence follows the definition of lactate threshold – *this is a moment when intensity of skeletal muscles effort as high that quantity of producing metabolic products in anaerobic glycolysis equals the abilities of mitochondria to utilize these products during TCA and oxidative phosphorylation.*

Determining lactate threshold by HR.

Using the HR method for the identification of lactate threshold showed high level of accuracy. In particular showed a 100% sensitivity, 95% specificity and 90% positive prediction value [4].

Determining lactate threshold by temperature.

There are not so many researches that estimated the concentration of lactate in blood and temperature changes. Here is an example.

20 men who train regular with a range of specializations have participated in the study (skiers, rock climbers etc.). The Nec TH9100SL infrared thermovision chamber was used to measure for forehead skin's temperature. These findings were contrasted with measurements of HR, gas exchange, peripheral blood lactate concentration, and anthropometric traits. It was demonstrated that two unequal groups may be formed from the dynamics of skin temperature at maximum work load: one (2/3 subjects, most of which trained endurance): the temperature decreases and the gradually rises until the subject refuses to work; two (1/3 subjects, pertraining to different sports specializations): the temperature drops from the moment active sweat evaporation begins until the work if terminated.

In first group lactate threshold, or blood lactate concentration of 4 mm/l, marks the start of a temperature rise following a drop in temperature brought on by sweat perspiration was actively evaporating [5].

As you can see the results are pretty indefinite. But due to physiology increasing of quantity of energy supply processes like glycolysis should have an impact on temperature. That's why it's necessary to run a correlation test with a great number of subjects.

Determining lactate threshold by breath frequency.

It's commonly known that reaching lactate threshold leads to pH decreasing. This phenomenon is called metabolic acidosis. One of compensation reaction of this process is increasing respiratory rate. That's why this is a significant variable for evaluating individual's anaerobic threshold. But there are some researches that claim the opposite: for the majority of participants, the field-based evaluation pf the lactate or ventilatory thresholds during running exercise is not feasible using the breathing frequency breakpoint [5].

This is the reason to perform a test which provides the necessary data (correlation between breath frequency and lactate concentration in blood.

Determining lactate in biological fluids.

Numerous studies have shown that the content of lactate in biological fluids (sweat, tears, saliva) and blood are strictly correlated:

- there is a strict connection between lactate levels in human tear samples and plod samples (R=0.977) [6];

- rat blood samples and human blood samples were examined to determine the amount of lactate present before and after vigorous physical exercise. The potential variation was obtained for both fluids, and the proposed method corroborated the human sweat response in comparison to the portable device's lactate assay in blood [6];
- there is a positive correlation (r>0.8 and r>0.7, respectively) between the variable rates of lactate concentration in sweat from working and latent muscle regions and blood lactate levels [7];
- correlations were discovered between the rise in blood and sweat lactate concentrations. Sweat lactate concentrations can be utilized to assess changes on blood lactate levels [8].

But there are researches with opposite results:

- there is no correlation between lactate concentration in sweat samples and in blood samples [9].

The fact that results are diametrically opposed the tests aimed at identifying correlation of blood and biological fluids lactate must carried out. It's also very important to pay extra attention on the way the sample is collected.

Conclusions

Despite the wide range of studies conducted in the area of determining lactate threshold through mediating variables, results and opinions vary widely. Whence the conclusion that one must conduct one's own research from which one can conclude the truth or falsity of the existing literature. This stage will allow the design of the device to progress significantly as it will finalise the concept of the device, in particular:

- the parameters required to be read (temperature, respiratory rate, etc.);
- the sensors to be used to detect biological fluids, and importantly, the choice of the fluid to be analysed.

The sensors are the defining part for the design of the device, since the parameters of the signal to be read completely determine the hardware, which in turn will determine the software.

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